ANALYSIS OF ANTERIOR SOFT TISSUE THICKNESS USING ULTRASONOGRAM, BODY MASS INDEX AND NECK CIRCUMFERENCE IN PREDICTING DIFFICULT INTUBATION

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CERTIFICATE

This is to certify that the dissertation entitled, "***ANALYSIS OF ANTERIOR SOFT TISSUE THICKNESS USING ULTRASONOGRAM, BODY MASS INDEX AND NECK CIRCUMFERENCE IN PREDICTING DIFFICULT INTUBATION***" submitted by **Dr.B.RAVINDRAN** in partial fulfillment for the award of the degree of Doctor of Medicine in Anesthesiology by the Tamilnadu Dr.M.G.R. Medical University, Chennai is a bonafide record of the work done by him in the Department of Anesthesiology, Madras Medical College, during the academic year 2007 -2010.

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Last but not least, I thank all the patients for willingly submitting themselves for this study.

CONTENTS

INTRODUCTION

AIRWAY ASSESSMENT

The purpose of undertaking airway assessment is to diagnose the potential for difficult airway for:

a. Optimal patient preparation

b. Proper selection of equipment and technique, and

c. Participation of personnel experienced in the difficult airway management.

This usually leads to a successful airway management. On the other hand, determining that the airway is normal, avoids time consuming, invasive, and potentially more traumatic methods of securing the airway, from being adopted.

The essential components of airway assessment are history taking, general examination of the patient and specific tests/indices to predict difficult airway.

Previous anesthesia records may reveal a documented history of difficult airway. History of previous surgery, burns, trauma or tumor in and around the oral cavity, neck or cervical spine should be asked.

A general examination of the patient should include recognition of anatomic factors that cause difficult laryngoscopy and intubation. This requires a disciplined, complete examination. The anesthesiologist must understand and identify pathologic and physiologic factors that may impair laryngoscopy and intubation.

Carrying out assessment tests/indices of difficult airway should follow a general examination and if time permits, try to use more than one assessment method to increase the accuracy of airway assessment.

DIFFICULT AIRWAY

Difficult airway clinical situation in which a conventionally trained anesthesiologist experiences difficulty with face mask ventilation of the upper airway, difficult tracheal intubation (or) both.

ULTRASONAGRAM TO MEASURE THE PRETREACHEAL SOFT TISSUE THICKNESS

Patient shifted to ultrasongram room and measures the pretreacheal soft tissue thickness at three levels:

1. Vocal cords (Zone I)
2. Thyroid isthmus (Zone II)
3. Suprasternal notch (Zone III)

NECK CIRCUMFERENCE :

Measured in cm at the level of thyroid notch.

BODY MASS INDEX

Body mass index is the body weight in kilograms over height in meters squared.

AIM OF STUDY

The aim of the study is to analyse pretracheal soft tissue using ultrasonagram, body mass index and neck circumference in predicting intubation difficulties.

BASICS OF ULTRASOUND AND EQUIPMENT

Ultrasound is a form of mechanical sound energy that travels through a conducting medium (e.g.body tissue) as a longitudinal wave producing alternating compression (high pressure) and rarefaction (low pressure). Sound propagation can be represented in a sinusoidal waveform with frequency (F), period (T), and velocity (speed (c) + direction).

The frequency of an ultrasound wave is above 20,000 Hz (or 20 KHz) and medical ultrasound commonly is in the 2.5-15 MHz range Human hearing is in the 20-20,000 Hz range. The average speed of ultrasound waves in biological tissue is 1,540 metres per second.

An ultrasound wave is generated when an electric field is applied to an array of piezoelectric crystals located on the transducer surface. Electrical stimulation causes mechanical distortion of the crystals resulting in vibration and production of sound waves (i.e. mechanical energy}. The conversion of electrical to mechanical (sound) energy is called the converse piezoelectric effect.

Each piezoelectric crystal produces an ultrasound wave. The summation of all waves generated by the piezoelectric crystals forms the ultrasound beam. Ultrasound waves are generated in pulses (intermittent trains of pressure waves) and each pulse commonly consists of 2 or 3 sound cycles of the same frequency.

The pulse length (PL) is the distance traveled per pulse. Waves of short pulse lengths improve axial resolution for ultrasound imaging. Pulse Repetition Frequency (PRF) is the rate of pulses emitted by the transducer (number of pulses per unit time). Ultrasound pulses must be spaced with enough time between pulses to permit the sound to reach the target of interest and return to the transducer before the next pulse is generated.

An ultrasound image is generated when the pulse wave emitted from the transducer is transmitted into the body, reflected off the tissue interface and returned to the transducer.

The transducer waits to receive the returning wave (i.e. echo) after each pulsed wave. The transducer transforms the echo (mechanical energy) into an electrical signal which is processed and displayed as an image on the screen. The conversion of sound to electrical energy is called the piezoelectric effect.

The image can be displayed in a number of modes'

1) amplitude (A) mode;

2) brightness (B) mode and

3) motion (M) mode.

Among the 3 modes, the B mode is most commonly used for ultrasound guicied regional anesthesia

There are 5 basic components of an ultrasound scanner that are required for generation, display and storage of an ultrasound image

1. **Pulser** - applies high amplitude voltage to energize the crystals

2. **Transducer** - converts electrical energy to mechanical (ultrasound) energy and vice versa

3. **Receiver** - detects and amplifies weak signals

4. **Display** - displays ultrasound signals in a variety of modes

5. **Memory** - stores video display

As the ultrasound beam travels through tissue layers, the amplitude of the original signal becomes attenuated as the depth of penetration increases. **Attenuation** (energy loss) is due to:

1) absorption (conversion of acoustic energy to heat);

2) reflection and

3) scattering at interfaces.

In soft tissue, 80% of the attenuation of the sound wave is caused by **absorption** resulting in heat production. Attenuation is measured in decibels per centimeter of tissue and is represented by the attenuation coefficient of the specific tissue type .

The higher the **attenuation coefficient,** the more attenuated the ultrasound wave is by the specified tissue For example, bone with a very high attenuation coefficient severely limits beam transmission. The degree of attenuation also varies directly with the frequency of the ultrasound wave and the distance traveled. Generally speaking, a high frequency wave is associated with high attenuation thus limiting tissue penetration, whereas a low frequency wave is associated with low tissue attenuation and deep tissue penetration.

To compensate for attenuation, it is possible to amplify the signal intensity of the returning beam, also called an echo. The degree of receiver amplification is called the gain. Increasing the gain will amplify only the returning signal and not the transmit signal.

When an echo returns to the transducer, its amplitude is represented by the degree of brightness (i.e. echogenicity) of a dot on the display.

Combination of all the dots forms the final image. Strong specular reflections give rise to bright dots **(hyperechoic)** e.g., diaphragm, gallstone, bone, pericardium. Weaker diffuse reflections produce grey dots **(hypoechoic)** e.g , solid organs. No reflection produces dark dots **(anechoic)** e.g , fluid and blood filled structures because the beam passes easily through these structures without significant reflection. Also, deep structures often appear **hypoechoic** because attenuation limits beam transmission to reach the structures, resulting in a weak returning echo.

Tissue	Ultrasound image for regional anesthesia
Veins	anechoic (compressible)
Arteries	anechoic (pulsatile)
Fat	hypechoic with irregular hyperechoic lines
Muscles	heterogeneour (mixture of hyperechoic lines within a hypoechoic tissue background)
Tendons	predominatly hyperechoic technical artifact (hypoechoic)
Bone	++ hyperechoic lines with a hypoechoic shadow
Nerves	hyperechoic / hypoechoic technical artifact (hypoehoic)

Nerves exhibit the phenomenon of anisotropy i.e. the echogenicity of the nerve varies with the angle of insonation. At 90", the reflection from the scanned nerve is maximal and the image is best

Spatial resolution determines the degree of image clarity. Resolution is the ability of the ultrasound machine to distinguish two structures that are close together as separate. Spatial resolution is influenced by **axial** and **lateral** resolution, both of which are closely related to ultrasound frequency.

Axial resolution refers to the ability to distinguish two structures that lie along the axis (i.e. parallel) of the ultrasound beam as separate and distinct. Axial resolution is determined by the pulse length. Ahigh frequency

Lateral resolution refers to resolution of objects lying side by side (i.e., perpmndicular to the beam axis). Lateral resolution is directly elated to the transducer **beam width,** which in turn is inversely related to the ultrasound frequency.

A high frequency transducer emits a wave with a short wavelength and a small beam width. The beam width can be further reduced by adjusting the **focal zone** (FZ). Lateral resolution is the best at the FZ, where the beam is narrowest. It is therefore clinically useful to focus the target structure within the focal zone to yield the best possible lateral resolution. A high frequency beam has a narrower beam width.

Colour Doppler is an instrument to characterize blood flow and is useful in identifying blood vessels in close proximity of which lie nerves or plexi. The Doppler effect occurs when there is a moving source (blood flow of red blood cells, RBC) and a stationary listener (ultrasound transducer). There is an apparent change in the returning echoes due to the relative motion between the sound source and the receiver. If the source (RBC) is moving **towards** the receiver (transducer), the perceived frequency is **HIGHER** (display in **RED**) and when the source (RBC) is moving away from the receiver, the perceived frequency is **LOWER** than the actual (display in **BLUE**).

Transducer characteristics, such as frequency and shape, determine ultrasound image quality. The transducer frequencies used range from 3-15 MHz. Linear and curvilinear (or curved) transducers are most useful to provide high resolution images. Modern transducers are broad bandwidth transducers that are designed to generate more than one frequency. For example, a 5-12 MHz transducer can generate waves ranging in frequency from 5-12 MHz. With broad bandwidth transducers, the operator can select the examination frequency to match the target requirement.

For superficial structures it is ideal to use high frequency transducers greater than or equal to 7 MHz. Transducers in the range of 10-15 MHz are preferred but depth of penetration is often limited to 2-3 cm below the skin surface. For visualization of deeper structures it may be necessary to use a lower frequency transducer (less than or equal to 7 MHz) because it offers ultrasound penetration of 4-5 cm or more below the skin surface. However, the image resolution is often inferior to that obtained with a higher frequency transducer.

IT IS IMPORTANT TO REMEMBER THAT:

high frequency - high spatial resolution but

limited depth of penetration

low frequency - greater depth of penetration

but lower spatial resolution

BODY MASS INDEX

CLASSIFICATION	BMI: $KG.M^2$
Normal	18.5 - 24.9
Overweight	$\geq$ 25
Pre-obesity	25 - 29.9
Obese Class - I	30 - 34.9
Obese Class - II	35 - 39.9
Obese Class - III	$\geq$ 40

NECK CIRCUMFERENCE

The incidence of difficult intubation in obese patients with large necks and OSA is claimed to be several times more frequent than in non- obese patients. A recent study concluded that obese patients with neck circumference > 50 cm had a greater chance of problematic intubations than those with < 50 cm.

REVIEW OF LITERATURE

1. Prediction of Difficult Laryngoscopy in Obese Patients by Ultrasound Quantification of Anterior Neck Soft Tissue

1. T. Ezri, 1) G. Gewürtz, 2) D.I. Sessler, 3) B.Medalion, 4) P. Szmuk, 5) C. Hagberg, and 6) S. Susmallian71 Department of Anaesthesia, Wolfson Medical Centre, Holon, Israel.

Abstract

Prediction of difficult laryngoscopy in obese patients is challenging. In 50 morbidly obese patients, we quantified the neck soft tissue from skin to anterior aspect of trachea at the vocal cords using ultrasound. Thyromental distance < 6 cm, mouth opening < 4 cm, limited neck mobility, Mallampati score > 2, abnormal upper teeth, neck circumference > 45 cm, and sleep apnoea were considered predictors of difficult laryngoscopy. Of the nine (18%) difficult laryngoscopy cases, seven had obstructive sleep apnoea history; whereas, only 2 of the 41 easy laryngoscopy patients did (P <0.001). Difficult laryngoscopy patients had larger neck circumference [50 (3.8) vs. 43.5 (2.2) cm; P < 0.001] and more pre-tracheal soft tissue [28 (2.7) mm vs. 17.5

(1.8) mm; P < 0.001] [mean (SD)]. Soft tissue values completely separated difficult and easy laryngoscopies. None of the other predictors correlated with difficult laryngoscopy. Thus, an abundance of pretracheal soft tissue at the level of vocal cords is a good predictor of difficult laryngoscopy in obese patients.

2. Ultrasound quantification of anterior soft tissue thickness fails to predict difficult laryngoscopy in obese patients.

Komatsu R, Sengupta P, Wadhwa A, Akça O, Sessler DI, Ezri T, Lenhardt R.

Anaesth Intensive Care. 2007 Feb;35(1):32-7.

Morbid obesity is associated with difficult laryngoscopy and intubation. In the general population, bedside indices for predicting difficult intubation (i.e. Mallampati classification, thyromental distance, sternomental distance, mouth-opening and Wilson risk score) have poor-to-moderate sensitivity (20-62%) and moderate-to-fair specificity (82-97%). In the obese population, although the risk of difficult intubation after a positive Mallampati test is 34%, it is still not sufficient to be used as a single predictive test. An abundance of pretracheal soft tissue anterior to the vocal cords, as quantified by ultrasound, was a better predictor of difficult laryngoscopy than body mass index (BMI) in Israeli patients. Obesity is a growing problem in the United States: therefore we sought to confirm this finding in the obese population in the United States. We used ultrasound to quantify the neck soft tissue, from the skin to the anterior aspect of the trachea at the vocal cords, in 64 obese patients (BMI > 35). We assessed thyromental distance, mouth-opening, jaw movement, limited neck mobility, modified Mallampati score, abnormal upper teeth, neck circumference, confirmed obstructive sleep apnoea, BMI, age, race and gender as predictors. Twenty patients were classified as difficult laryngoscopy; they were older (47 +/- 9 vs 42 +/- 1 years; P = 0.048; mean +/- SD) and had less soft pretracheal tissue (20.4 +/- 3.0 vs 22.3 +/- 3.8 mm; P = 0.049) than did easy laryngoscopy patients. Multivariate regression indicated that none of the factors was an independent predictor of difficult laryngoscopy. We conclude that the thickness of pretracheal soft tissue at the level of the vocal cords is not a good predictor of difficult laryngoscopy in obese patients in the United States.

3. Preoperative airway assessment: predictive value of a multivariate risk index

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Using readily available and objective airway risk criteria, a multivariate model for stratifying risk of difficult endotracheal intubation was developed and its accuracy compared to currently applied clinical methods. We studied 10,507 consecutive patients who were prospectively assessed prior to general anesthesia with respect to mouth opening, thyromental distance, oropharyngeal (Mallampati) classification, neck movement, ability to prognath, body weight, and history of difficult tracheal intubation. After induction of anesthesia, the laryngeal view during rigid laryngoscopy was graded and the ability of experienced anesthesia personnel to ventilate via a mask was determined. Poor intubating conditions (laryngoscopy Grade IV) and inability to achieve adequate mask ventilation were identified in 107 (1%) and 8

(0.07%) cases, respectively. Logistic regression identified all seven criteria as independent predictors of difficulty with laryngoscopic visualization. A composite airway risk index (derived from nominalized odds ratios calculated from the multivariate model) as well a simplified (0 = low, 1 = medium, 2 = high) risk weighting exhibited higher positive predictive value for laryngoscopy Grade IV at scores with similar sensitivity to Mallampati class III, as well as higher sensitivity at scores with similar positive predictive value. Compared to Mallampati class I fewer false-negative predictions were observed at a risk index value of 0. We conclude that improved risk stratification for difficulty with visualization during rigid laryngoscopy (Grade IV) can be obtained by use of a simplified preoperative multivariate airway risk index, with better accuracy compared to oropharyngeal (Mallampati) classification at both low- and high-risk levels.

4. **The importance of increased neck circumference to intubation difficulties in obese patients.**

Gonzalez H, Minville V, Delanoue K, Mazerolles M, Concina D, Fourcade O. Department of Anesthesiology and

Intensive Care, University Hospital of Toulouse, Toulouse, France.

BACKGROUND: Using the intubation difficulty scale (IDS), we sought to confirm that obese patients are more difficult to intubate than lean patients. We assessed classical bedside tests and included neck circumference. METHODS: We prospectively compared the incidence of difficult tracheal intubation in 70 obese [body mass index (BMI) > or = 30 kg/m(2)] and 61 lean patients (BMI < 30 kg/m(2)). The IDS scores, categorized as difficult intubation (IDS > 5) or not (IDS < or = 5), and the patient data, were compared between lean and obese patients. Preoperative measurements [BMI, neck circumference (at the level of the thyroid cartilage), width of mouth opening, sternomental distance, and thyromental distance], medical history of obstructive sleep apnea syndrome, and several scores (Mallampati, Wilson, El Ganzouri) were recorded. The view during direct laryngoscopy was graded, and the IDS was recorded. We then compared patients with IDS < or = 5 and > 5, concerning each item. RESULTS: The results indicate that difficult tracheal intubation is more frequent in obese than in lean patients (14.3% vs 3%; P =

0.03). In the patients with IDS > 5, thyromental distance, BMI, large neck circumference, and higher Mallampati score were the only predictors of potential intubation problems. CONCLUSION: We found that problematic intubation was associated with thyromental distance, increasing neck circumference, BMI, and a Mallampati score of > or = 3. Neck circumference should be assessed preoperatively to predict difficult intubation.

5. ULTRASOUND GUIDED AIRWAY ASSESSMENT

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Introduction: Airway management has been the most important aspect of anesthesia. Mismanagement of airway has been the single major cause for morbidity and mortality related to anesthesia. It is also the most common cause of litigation against anesthesiologists. Thus, any tool that improves airway assessment will be extremely valuable for the safe practice of anesthesia. Though X-ray, CT scan and MRI have been used to study airway and predict difficult intubation(1), their size, radiation risk and cost limits their routine use. Ultrasound (US) has the advantages of being safe, compact and portable. We propose US as a useful tool to scan the anterior neck in all adult patients to identify the airway structures and measure variables that may assist airway assessment.

Methods: After research and ethics board approval we conducted an observational study to scan 30 patients who will require intubation for their surgery. After informed consent, all patients underwent a clinical and US examination of the anterior neck. The US parameters measured were: thickness of the tongue, submental thickness, depth of epiglottis, angle of epiglottis, thyrohyoid distance, angle of line of vision (Figure 1), depth of arytenoid cartilages. US scan was performed with the help of a trained radiographer who was blinded to intubation details. The grade of laryngoscopy view, dietails of intubation were obtained from the anesthetic chart and the anesthesiologist. The parameters were compared between the easy laryngoscopy(Cormack & Lehane grade 1 and 2) and the difficult laryngoscopy (C&L grade 3 and 4) patients. We also identified the most appropriate view and the transducer for each of the pertinent airway structures involved.

Results: The significant parameters were the angulation of the epiglottis and the angle of line of vision. Further details of the measured parameters, transducer used and best plane of view for airway structures will be presented.

Discussion: US helps us to see structures like epiglottis, angle of epiglottis and line of vision which may be useful in airway assessment. Further studies are required to evaluate if these parameters can be used to develop a predictive model for difficult laryngoscopy.

6. Relationship between body mass index, age and upper airway measurements in snorers and sleep apnoea patients

P Mayer, JL Pepin, G Bettega, D Veale, G Ferretti, C Deschaux, and P Levy

Anatomical pharyngeal and craniofacial abnormalities have been reported using upper airway imaging in snorers with or without obstructive sleep apnoea (OSA). However, the influences of the age and weight of the patient on these abnormalities remain to be established. The aim of this study was, therefore, to evaluate in a large population of snorers with or without OSA, the relationship between body mass index (BMI), age and upper airway morphology. One hundred and forty patients were referred for assessment of a possible sleep-related breathing disorder and had complete polysomnography, cephalometry and upper airway computed tomography. For the whole population, OSA patients had more upper airway abnormalities than snorers. When subdivided for BMI and age, however, only lean or younger OSA patients were significantly different from snorers as regards their upper airway anatomy. The shape of the oropharynx and hypopharynx changed significantly with BMI both in OSA patients and snorers, being more spherical in the highest BMI group due mainly to a decrease in the transverse axis. On the other hand, older patients (> 63 yrs), whether snorers or apnoeics, had larger upper airways at all pharyngeal levels than the youngest group of patients (< 52 yrs). For the total group of patients, upper airway variables explained 26% of the variance in apnoea/hypopnoea index (AHI), whereas in lean (BMI < 27 kg.m-2) or youngest (age < 52 yrs) subjects upper airway variables explained, respectively 69 and 55% of the variance in AHI. In conclusion, in lean or young subjects, upper airway abnormalities explain a major part of the variance in apnoea/hypopnoea index and are likely to play an important physiopathogenic role. This study also suggests that the shape of the pharyngeal lumen in awake subjects is more dependent on body mass index than on the presence of obstructive sleep apnoea. Further investigation looking at upper airway imaging for surgical selection in obstructive sleep apnoea should focus on lean and young patients.

7. Correlation between retroglossal airway size and body mass index in OSA and non-OSA patients using cone beam CT imaging.

Shigeta Y, Enciso R, Ogawa T, Shintaku WH, Clark GT.

Orofacial Pain/Oral Medicine Center, Division of Diagnostic Sciences, School of Dentistry, University of Southern California, Los Angeles, CA, USA.

Most obstructive sleep apnea (OSA) patients are overweight, and OSA is substantially more common in obese individuals. In morbidly obese patients, at least 70% suffer from OSA. However, the exact mechanism by which obesity causes OSA is unclear. The aim of this study is to evaluate the retroglossal airway configuration quantitatively and to make clear the relationship between Body mass index (BMI) and airway configuration. This retrospective study included 15 OSA patients (male = 11; female = 4) and 14 normal controls (male = 8; female = 6). We studied the airway configuration on an axial slice at the level of the anterior-inferior corner of the second cervical vertebra. Maximum anterior-posterior diameter (AP) and lateral width (LW) of the airway were measured, and the square area (SA) was calculated.

The airway cross-section area (AWA) was also measured, and then the AWA/SA ratio was calculated. AP, LW, and AWA were not statistically significantly different between controls and OSA patients. On the other hand, the AWA/SA ratio in OSA patients was 8.8% statistically significantly smaller than in controls after adjusting for sex, age, and BMI. In this sample, there was a negative correlation between age and the AWA/SA ratio but only in the OSA group.

The AWA/SA ratio was significantly negatively correlated with OSA status ($R = -0.5$; $p = 0.008$) after adjusting for BMI and age. In this present study, we could evaluate the retroglossal airway configuration quantitatively. The AWA/SA ratio was correlated with OSA status after adjusting for BMI and age.

8. **Morbid obesity and tracheal intubation.**

Brodsky JB, Lemmens HJ, Brock-Utne JG, Vierra M, Saidman LJ.

Department of Anesthesia, Stanford University School of Medicine, Stanford, California 94303, USA. Jbrodsky@leland.stanford.edu.

The tracheas of obese patients may be more difficult to intubate than those of normal-weight patients. We studied 100 morbidly obese patients (body mass index > 40 kg/m(2)) to identify which factors complicate direct laryngoscopy and tracheal intubation. Preoperative measurements (height, weight, neck circumference, width of mouth opening, sternomental distance, and thyromental distance) and Mallampati score were recorded. The view during direct laryngoscopy was graded, and the number of attempts at tracheal intubation was recorded. Neither absolute obesity nor body mass index was associated with intubation difficulties. Large neck circumference and high Mallampati score were the only predictors of potential intubation problems. Because in all but one patient the trachea was intubated successfully by direct laryngoscopy, the neck circumference that requires an intervention such as fiberoptic bronchoscopy to establish an airway remains unknown. We conclude that obesity alone is not predictive of tracheal intubation difficulties. IMPLICATIONS: In 100 morbidly obese patients, neither obesity nor body mass index predicted problems with tracheal intubation. However, a high Mallampati score (greater-than-or-equal to 3) and large neck circumference may increase the potential for difficult laryngoscopy and intubation.

9. Neck Circumference and Difficult Intubation

Vincent Minville, MD, Hélène Gonzalez, and Olivier Fourcade

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Finally, when searching for factors predicting difficult intubation, we need to define both specificity as well as sensitivity of the test. Neck circumference alone is a sensitive test (92%) meaning that NC < 43 tracheal intubation will probably be uneventful. In combination with Mallampati's score, it becomes more specific (92%) meaning that, if both NC > 43 and Mallampati > 3, tracheal intubation will probably be difficult. In other words, although not a perfect predictor of difficult intubation, NC is a useful and easily performed bedside test that helps the anesthesiologist in the matter of airway assessment. However, we agree with Hassani and Kessell,1 that this cutoff value has to be assessed prospectively.

10. Predicting Difficult Intubation in Apparently Normal Patients: A Meta-analysis of Bedside Screening Test Performance

Shiga, Toshiya M.D., Ph.D.; Wajima, Zen'ichiro M.D., Ph.D.; Inoue, Tetsuo M.D., Ph.D.; Sakamoto, Atsuhiro M.D., Ph.D.

The objective of this study was to systematically determine the diagnostic accuracy of bedside tests for predicting difficult intubation in patients with no airway pathology. Thirty-five studies (50,760 patients) were selected from electronic databases. The overall incidence of difficult intubation was 5.8% (95% confidence interval, 4.5-7.5%). Screening tests included the Mallampati oropharyngeal classification, thyromental distance, sternomental distance, mouth opening, and Wilson risk score. Each test yielded poor to moderate sensitivity (20-62%) and moderate to fair specificity (82-97& percnt;). The most useful bedside test for prediction was found to be a combination of the Mallampati classification and thyromental distance (positive likelihood ratio, 9.9; 95% confidence interval, 3.1-31.9). Currently available screening tests for difficult intubation have only poor to moderate discriminative power when used alone. Combinations of tests add some incremental diagnostic value in comparison to the value of each test alone. The clinical value of bedside screening tests for predicting difficult intubation remains limited.

METHODOLOGY

It was a prospective, double blinded study conducted in Department of Anaesthesiology, Madras Medical College-GGH.

200 adult patients satisfying inclusion criteria were enrolled in this study.

INCLUSION CRITERIA:

- Elective adult surgical patient requiring general endotracheal anaesthesia.
- Males and Females.
- ASA Physical Status 1-2.
- Age 18 years of age and older.
- Who have given valid informed consent.

EXCLUSION CRITERIA:

The patients with following conditions are not included in this study.

- Patients not satisfying inclusion criteria.

- Patients requiring special techniques for intubation such as rapid sequence induction.
- Patients intubated prior to surgery.
- Patients with severe cardiovascular, hepatic or renal disease, mental illness.
- Are unconscious or very severely ill.
- Need for nasal intubation.

Materials :

- Macintosh laryngoscope - current standard Device.
- High frequency (7.5mhz) Ultrasound machine.
- Weighing machine calibrated to 1 Kg.
- Measuring tape calibrated to 0.5 cm.
- Goniometer

AIRWAY ASSESSMENT:

Previous anaesthesia records, H/O snoring, H/O voice change, H/O previous surgery, Trauma, Burns, Tumour in & around the oral cavity, Neck or cervical spine were asked in the history. H/O of systemic illness like Diabetes, Ankylosing spondylitis, Rheumatoid arthritis were asked andrecorded.

General examination included examination for facial anomalies, Tempero-mandibular joint pathology, Anomalies of mouth & tongue, pathology of nose, pathology of palate. Height in metre and weight in kilograms were recorded and BMI calculated.

Measurement of airway indices : Individual indices were measured.

A-0 joint movement: Patient was asked to look the ceiling without raising eyebrow and the range of movements measured with gonioscope.

Neck flexion : Patient was asked to touch the manubrium sterni with chin and the range of movements measured with gonioscope.

TMJ function : the patient was asked to open his mouth wide open and the inter incisor distance measured. Examinrs index finger was placed in front of the tragus and thumb over the mastoid process-the patient was asked to open the jaw and sliding fuction of themandibular condyle was assed.

Upper lip bite test: the patient was asked to bite the upper lip with the lower incisor and graded as follows:

Class 1: lower incisor can bite the upper lip above the vermilion line.

Class 2 : lower incisor can bite the upper lip below the vermilion line.

Class 3: lower incisor cannot bite the upper lip.

Thyromental distance : distance between the thyroid notch and mental symphysis when the neck was fully extended and mouth closed.

Sternomental distance : distance between the sterna notch and mental symphysis when the neck was fully extended and mouth closed.

Examination of dentures : abnormalities like cracking, bucking, loose, artificial and absence of incisors were examined and recorded.

NECK CIRCUMFERENCE

The incidence of difficult intubation in obese patients with large necks and OSA is claimed to be several times more frequent than in non- obese patients. A recent study concluded that obese patients with neck circumference > 50 cm had a greater chance of problematic intubations than those with < 50 cm.

BODY MASS INDEX

CLASSIFICATION	BMI: $KG.M^2$
Normal	18.5 - 24.9
Overweight	$\geq$ 25
Pre-obesity	25 - 29.9
Obese Class - I	30 - 34.9
Obese Class - II	35 - 39.9
Obese Class - III	$\geq$ 40

Samsoon & young modification of Mallampati grading :

The patient kept in sitting position with maximal mouth opening, protruding tongue, without phonation and the observer's eye in level with patients mouth the degree to which faucial pillars, uvula, soft palate & hard palate were visible were recoded and classified as follows :

Grade I: faucial pillars, uvula, soft palate & hard palate visible

Grade II: uvula, soft palate & hard palate visible

Grade III: base of uvula or none , soft palate & hard palate visible

Grade IV : only hard palate visible

ULTRASONGRAM IN MEASURING PRETREACHIAL SOFT TISSUE THICKNESS

Patient shifted to ultrasongram room and measures the pretreachial soft tissue thickness at three levels:

1. Vocal cords (Zone I)
2. Thyroid isthmus (Zone II)

3. Suprasternal notch (Zone III)

The amount of soft tissue at each zone is calculated by averaging the amount of soft tissues in mm obtained in the central axis of the neck.

After assessment patient shifted to operating room, I.V line started and monitors connected. inj. Glucopyrrolate 0.2mg and Inj. Fentanyl 2ug/Kg given as premedication. Then preoxygenated with 100% oxygen for 3 min.

Induction done with inj. Thiopentone 5mg/kg+ NDP neuromuscularblocker-finj.Xylocard l.5mg /kg

Ventilated with face mask for 3 min; Quick look laryngoscopy done with Macintosh laryngoscope and the Cook's modification of Cormack-Lehane grading & intubation difficult score was noted.

Cook's modification of Cormack-Lehane grading and Intubation difficulty score were noted as follows :

CORMACK & LEHANE GRADING SYSTEM :

Entire vocal cord visualized	:	Grade-1
Posterior part of vocal cords seen	:	Grade IIa
Arytenoids only seen	:	Grade lIb

Epiglottis only seen (liftable)	:	Grade IlIa
Tip of epiglottis only seen / adherent	:	Grade Illb
No glottis structure seen	:	Grade IV

INTUBATION DIFFICULTY SCORE :

Seven variables are used :

- Nl- Number of supplementary attempts. An attempt is defined as one advancement of tracheal tube in the direction of the glottis during direct laryngoscopy.

- N2- The number of supplementary operators directly attempting (not assisting)

- N3 -The number of alternative techniques used.

- N4 - Glottic exposure as defined by the Cormack grade minus one.

- N5 - subjectively increased lifting force applied during laryngoscopy.

- N6-The necessity of external laryngeal pressure.

- N7 - Position of vocal cords. 0- abduction, 1- adduction

Apart from Cormack-Lehane and Intubation Difficulty score the following factor was also noted :

- Intubation time: Measured from entry of the device into the oral cavity until confirmation of proper placement of tracheal tube.

OBSERVATION AND RESULTS

This prospective, randomized, double blinded study predicting the intubating conditions with measuring anterior soft tissue thickness using ultrasonogram, Body mass index and Neck circumference and evaluated the advantages, effective airway time and airway trauma .

All data were collected and tabulated.

Statistical analysis were conducted using SSPC 13.0 version.

DEMOGRAPHIC VARIABLES :

200 patients were randomly selected and included in this study.

AGE DISTRIBUTION :

Age group of the patients range from 18 yrs to 70 yrs. Majority of the study population were in 18 to 30 yrs age group

Age (yrs)	18-30	31-40	41-50	51-60	61-70
N	66	37	49	45	3

SEX DISTRIBUTION :

- Among the study population 42% were male and 58% were female.

SEX	MALE	FEMALE
n	85	115
%	42	58

BODY MASS INDEX :

Body mass index of patients ranged from 18 to 45

BMI	≤ 20	21-25	26-30	31-35	≥ 35
N	50	61	48	21	17

MODIFIED MALLAMPATI CLASSIFICATION :

- Modified Mallampati score distribution was 60% / 26% / 12.4% / 1.6%.

MMC	**1**	**2**	**3**	**4**
N	159	33	9	0
%	79.5	16.5	1	0

ANTERIOR SOFT TISSUE THICKNESS :

Mm	**9.5 – 10.4**	**10.5 – 11.4**	**11.5 – 12.4**	**12.5 – 13.4**
N	**102**	**61**	**28**	**9**

Anterior soft tissue thickness measured at three levels (vocal cord, thyroid isthmus and supra sternal notch) and their mean value calculated and tabulated.

OTHER AIRWAY INDICES :

- Neck flexion ranged from 25^0 to 35^0. Neck extension ranged from 30^0 to 40^0.
- Sterno mental and thyromental distances ranged from 18.5 to 21 cm and 8 to 11 cm respectively.
- Inter incisor distance ranged from 3 to 5 cm.
- 5 patients had artificial dentures, 7 patients had buck tooth, 7 had loose tooth, and one patient was edentulous.
- In upper lip bite test 184 patients were score 1 and 16 patients were score 2.

OUTCOME MEASURES :

Cormack & Lehane grading :

Samsoon & young modification of Cormack & Lehane classification was used to grade laryngeal view

Cormack & Lehane	**1**	%	**2a**	%	**2b**	%	**3a**	%	**3b**	%	**4**	%
	176	88	**16**	8	**7**	3.5	**1**	0.5	**0**	0	**0**	0

INTUBATION DIFFICULTY SCORE :

IDS	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**∝**
n	170	5	9	12	2	2	0	0
7%	95	2.5	1.5	6	1	1	0	0

Intubation difficulty score of ‘0’ considered as EASY and more than and equal to ‘1’ considered as difficult.

IDS	**N**	**%**
EASY	170	85
DIFFICULT	30	15

BODY MASS INDEX AND IDS SCORING :

		< 20	21-25	26-30	31-35	> 35	
EASY	N	49	51	43	16	11	170
	Row %	28.8	30.0	25.3	9.1	6.5	85.0
	Col %	98.0	79.7	89.6	76.2	61.7	
DIFFICULT	N	1	13	5	5	6	30
	Row %	3.3	13.3	16.7	16.7	20.0	15.0
	Col %	2.0	20.3	10.1	23.8	35.3	
COLUMN		50	6 1	18	21	17	
TOTAL		25.0	32.0	21.0	10.5	8.5	

P = 0.00360

BMI in our study population is divided in five categories (< 20, 21-25, 26-30, 31-35, > 35) in patients with BMI < 20 only 2% population had difficult intubation.

But in patients with BMI >35 this value increased to 35.3 %. The correlation between BMI and difficult intubation was analysed with chi square test. The correlation was **statistically significant**.

ANTERIOR SOFT TISSUE THICKNESS AND IDS SCORING:

Anterior soft tissue thickness was assessed by Ultrasound at three levels and the mean values were categorized in four groups and analysed.

		9.5 – 10.4	**10.5 – 11.4**	**11.5 – 12.4**	**12.5 – 13.4**	
EASY	N	95	51	18	3	170
	Row %	55.9	31.9	10.6	1.8	85.0
	Col %	93.1	88.5	61.3	33.3	
DIFFICULT	N	7	7	10	6	30
	Row %	23.3	23.3	33.3	20.0	15.0
	Col %	6.9	11.5	35.7	66.7	
COLUMN		102	61	29	9	
TOTAL		51.0	30.5	11	1.5	

P=0.000**

In category 1 difficult intubation observed in 6.9% patients. But in category 4 difficult intubation noted in 66.4%. The results were analysed using Chi-square test and the correlation of increasing anterior soft tissue thickness with difficult intubation was statistically significant.

NECK CIRCUMFERENCE AND IDS SCORING :

		< 35	35-40	>40	
EASY	N	32	120	18	170
	Row %	18.8	70.6	10.6	85.0
	Col %	94.1	86.3	66.7	
DIFFICULT	N	2	19	9	30
	Row %	6.7	63.3	30.0	15.0
	Col %	5.9	13.7	33.3	
COLUMN		34	139	27	
TOTAL		17.0	69.5	13.5	

P = .00835

Neck circumferences of study population divided into three categories (< 35 cm/ 35-40cm/ > 40cm). In category 1 - 5.9% ; in category 2 - 13.7; and in category 3 - 33.3% population were difficult to intubate.

Results were analysed with chi square test and statistically significant correlation was obtained with increasing neck circumference and difficult intubation. This result is comparable with study conducted by Gonzalez H, Delanoue K, Mazerolles M, Concina D, Fourcade O.

DURATION :

Mean duration was 17 seconds. Range was 10 to 25 seconds. 58.8% were intubated in 10 to 15 seconds.

Seconds	10-15	16-20	> 20
n	135	58	7
%	67	29	3.5

TRAUMA:

In 5 patients minor degree of trauma noted. In 2 patients abrasion of lips , in 2 patients minor abrasion in pharynx and in 1 patients abrasion in base of epiglottis noted.

TRAUMA	LIPS	DENTURES	TONGUE	PALATE	PHARYNX	EPIGLOTTIS	LARYNX	Σ
N	2	0	0	0	3	0	0	5

DISCUSSION[1-17]

Expert airway management is an essential skill of an Anaesthesiologist

A "Difficulty airway" has been defined as the clinical situation in which a conventionally trained anesthesiologist experiences problems with mask ventilation, with teacheal intubation, or with both.

The incidence of difficult laryngoscopy and tracheal intubation is unknown, but it may be as frequent as 7.5% in the normal surgical population.

Difficulties with tracheal intubation are mostly caused by difficult direct laryngoscopy with impaired view to the vocal cords. Many difficult intubations will not be recognized until after induction of anaesthesia. Unanticipated difficult intubation can lead to critical situations, especially in those patients who are at risk for gastric regurgitation, who are difficult to ventilate by mask or who have limited cardio-pulmonary reserves.

The medical literature on this subject is confusing because multiple univariate and multivariate indices are proposed for predicting difficult intubation. Unfortunately, despite of all the information currently available, no single factor reliably predicts these difficulties .

There have been many attempts to develop a score to measure the complexity of endotracheal intubation. Most methods are quite complicated, involving numerous variables.

Factors that have been associated with difficult laryngoscopy include short Sternomental distance; short thyromental distance; large neck circumference; limited head, neck, and jaw movement; receding mandible; and prominent teeth.

Few published studies have focused on the distribution of fat in the anterior neck region and its correlation with difficult intubation.

Whittle et al. demonstrated the presence of excessive fat in the submandibular region predicting difficult intubation. The disposition of excessive soft tissue to the vellopalate, retropharynx, and submandibular regions may partially explain the mechanism of supraglottic airway collapse during sleep or anaesthesia. The increased amount of pre-tracheal neck soft tissue in these patients impaired laryngoscopy by reducing anterior mobility of pharyngeal structures.

Some studies demonstrated that, Quantification of neck soft tissue at the level of the vocal cords, thyroid isthmus and suprasternal notch was the best predictor of difficult laryngoscopy, with no overlap in values for the difficult and easy laryngoscopies.

MRI and CT scans have been used to demonstrate the presence of abundant soft neck tissue in the pharynx, retropharynx, suprascapular region, and lateral neck region of obese patients. However, MRI and CT scans are costly, may involve some risks to the patients, and require excessive time to be practical. Instead, ultrasound quantification of the anterior neck soft tissue can be a novel means of predicting difficult laryngoscopy.

From available literatures the advantages of ultrasound includes:

- as accurate as MRI for quantification of fat depth
- inexpensive

- rapid
- easy to perform
- no hazard of radiation (safe in obstetric population)
- can be done as bed side procedure
- reproducible
- comfortable
- safe in patients with pacemakers and prosthetic implants.

Factors responsible for difficult laryngoscopy and intubation in obese patients include :

- Fat face and cheeks
- Large breast in females
- Limited head, neck and jaw mobility
- Small mouth and large tongue
- Excessive palatal and pharyngeal tissue
- Short thick neck

- High Mallampati score

- Oxygen desaturation 65% more rapid

The patient with history of Obstructive Sleep Apnea and heavy snoring is a most likely candidate to go into difficult mask ventilation after induction of anesthesia. In obese patients adipose tissue deposits in the lateral pharyngeal wall; This deposits are not attached to bony structures and highly mobile.

They have tendency to protrude in the airway, thereby narrowing it and drawn further into the airway during negative airway pressure as patient tries to breath against an obstructed airway. As a result excessive adipose tissue tends to obstruct the airway even more during the inspiratory phase of spontaneously breathing patients.

This study was designed to evaluate the usefulness of Neck circumference, Pretracheal soft tissue and Body mass index in predicting difficult airway.

INTUBATION DIFFICULTY SCORE :

Intubation difficulty score was used to evaluate intubating conditions. It was developed by Adnet et al in 1997. It is a blend of subjective and objective criteria that permit a qualitative and quantitative approach to the progressive nature of the difficulty in intubation, and appears to be the best indicator till date.

In this scale, the value of IDS is '0' if full visualization of the laryngeal aperture is possible during laryngoscopy and vocal cords are seen to be nicely abducted. Each variation from this defined 'ideal' intubation increases the degree of difficulty, the overall score being the sum of all variations from the definition.

NECK CIRCUMFERENCE :

Neck circumferences of study population divided into three categories (<35 cm/ 35-40cm/ >40cm). In category 1 - 5.9% ; in category 2 - 13.7; and in category 3 - 33.3% population were difficult to intubate. Results were analysed with chi square test and statistically significant correlation was obtained with increasing neck circumference and difficult intubation. This result is comparable with study conducted by Gonzalez H, Delanoue K, Mazerolles M, Concina D, Fourcade O.

BODY MASS INDEX :

BMI in our study population is divided in five categories (<20, 21-25, 26-30, 31-35, >35) in patients with BMI < 20 only 2% population had difficult intubation. But in patients with BMI >35 this value increased to 35.3 %.

In study conducted by Gonzalez H, Delanoue K, Mazerolles M, Concina D, Fourcade O. they concluded that difficult tracheal intubation is more frequent in obese patients than in lean patients (14.3% vs 3.0%)

P Mayer, JL Pepin, G Bettega, D Veale, G Ferrati, P Levy conducted study on ‘ Relationship between body mass index, age and upper airway measurements’. They concluded that increasing BMI values increases the chance of upper airway obstruction.

In our study the correlation between BMI and difficult intubation was analysed with chi square test. The correlation was statistically significant. This is comparable to available literatures.

ANTERIOR SOFT TISSUE THICKNESS:

Anterior soft tissue thickness was assessed by Ultrasound at three levels and the mean values were categorized in four groups and analysed (9.5 – 10.4 / 10.5- 11.4 / 11.5-12.4 / 12.5-13.4 mm).

In category 1 difficult intubation observed in 6.9% patients. But in category 4 difficult intubation noted in 66.4%. the results were analysed using Chi-square test and the correlation of increasing anterior soft tissue thickness with difficult intubation was statistically significant.

In the study conducted by T Ezri, G Gewurtz, D I Sessler, B Medalion, P Szmuk, C Hagberg and S Susmalian, Department of Anaesthesia, Wolfson medical centre, Holon Israel, they concluded that ‘ Difficult laryngoscopy patients had larger neck circumference and ore pretracheal soft tissue. Soft tissue values completely separated easy and difficult laryngoscopies. Thus an abundance of pre tracheal soft tissue at the level of vocal cords is a good predictor of difficult laryngoscopy in obese patients.

AIRWAY TRAUMA :

- Minor degree of airway trauma noted in 5 patients.
- 3 patients had abrasion of lips; 2 patients had minor abrasion in pharynx

In the study conducted by Ishwar singh, abhijit khaund, Abhishek gupta, Department of Anaesthesiology,Jaipur Golden Hospital, New Delhi, No significant complication like oro-pharyngeal trauma or extreme pressor response was noted.

Acute traumatic complications Injury to the lips, teeth, tongue, nose, pharynx, larynx, trachea and bronchi can occur during laryngoscopy and intubation. Traumatic complications have been extensively described in two excellent reviews.

1. Weber S. Traumatic complications of airway management. Anesthesiology Clinics of North America 2002; 20: 503-512. and in

2. Loh KS, Irish JC. Traumatic complications of intubation and other airway management procedures. Anesthesiology 2002; 20: quoting that "Minor trauma to the airway is common and incidence increases with increasing duration , increasing grade of difficulty, female gender and > 60 yrs age. Most traumatic complications do not result in major

morbidity or mortality. However, some require immediate recognition and management."

INTUBATION DURATION :

- The mean time to intubate was 15 seconds.
- Intubation time range was 10 to 25 seconds.
- 67.5% were intubated in 10 to 15 seconds.

In the study conducted by Ishwar singh, Abhijit khaund, Abhishek gupta, Department of Anaesthesiology,Jaipur Golden Hospital, New Delhi, intubation was possible in 88% of cases within stipulated time of one minute and mean time of 28.6 seconds.

The study conducted by Y. Toyama , N. Katsumi , T. Kunisawa , R. Sasaki K. Hirota the mean (SD) time required to place the tracheal tube was 20 seconds.

SUMMARY

This study was conducted in the Department of Anaesthesiology, Madras Medical College, Chennai-3.

200 patients were selected randomly and after taking history, airway assessment, anterior soft tissue thickness using ultrasound, Body mass index and neck circumference taken up for the study.

After analysing the statistical data it is found that the anterior soft tissue thickness using ultrasound, Body mass index and neck circumference, significantly predicted the difficult intubation.

CONCLUSION

It can be concluded that the anterior soft tissue thickness using ultrasound, Body mass index and Neck circumference, significantly predicted the difficult intubation and can be an important aid for the anaesthesiologist.

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PROFORMA

NAME : AGE : SEX : I.P. NO :

DIAGNOSIS : SURGERY PLANNED :

PRE OPERATIVE ASSESSMENT :

HISTORY :

CO-MORBID ILLNESS & TREATMENT DETAILS -

EFFORT TOLERANCE - _______METS.

H/O PREVIOUS SURGERY (ANY DOCUMENTED DIFFICULT AIRWAY) –

H/O TRAUMA/ BURNS/ TUMOURS INVOLVING AIRWAY –

H/O SNORING –

H/O VOICE CHANGE –

GENERAL EXAMINATION :

HEIGHT : WEIGHT : **BMI:**

ANAEMIA- JAUNDICE- CERVICAL SPINE : TONGUE :

PR- BP- CVS- RS -

AIRWAY EXAMINATION :

GROSS ALTERATION IN AIRWAY ANATOMY :

HAIR BUN : BEARD:

NECK FLEXION : NECK EXTENSION :

INTER INCISOR DISTANCE : THYRO MENTAL DISTANCE :

STERNO MENTAL DISTANCE : NEUTRAL : MAX. EXTENSION with mouth closed :

UPPER LIP BITE TEST : **NECK CIRCUMFERENCE :**

RECEDING MANDIBLE : PALATE CONFIGURATION :

ANTERIOR SOFT TISSUE THICKNESS :

site	Vocal cord	Thyroid isthmus	Supra sternal notch	Mean
mm				

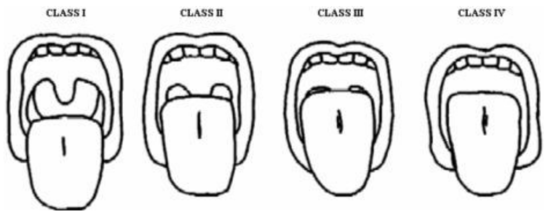
DENTURES :

ARTIFICIAL (REMOVABLE / FIXED) : BUCK TEETH : UPPER INCISOR

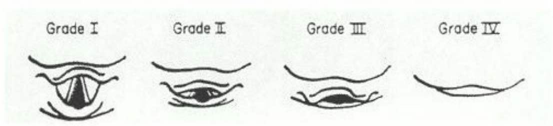
LENGTH :

LOOSE TEETH : CRACKED TEETH : ABSENT TEETH :

MODIFIED MALLAMPATI CLASSIFICATION : (mark- O)



COOKS MODIFICATION OF CORMACK & LEHANE GRADING :



a b a b

- NUMBER OF ATTEMPTS :
- NUMBER OF SUPPLEMENTRY OPERATORS :
- NUMBER OF ALTERNATIVE TECHNIQUES : (change of blade / use of bougie):
- CORMACK & LEHANE GRADE minus 1 :
- LIFTING FORCE :
- EXTERNAL LARYNGEAL MANIPULATION : (needed / not needed) :
- POSITION OF VOCAL CORDS : (abducted / adducted) :

N1	N2	N3	N4	N5	N6	N7

DURATION : _____ SECONDS

AIRWAY TRAUMA :